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Coherent ULF waves in Mercury's nightside magnetosphere: Their source and impact

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Coherent ultra-low-frequency (ULF) waves at frequencies between 0.2 and 3 Hz in Mercury's inner magnetosphere ($R < 2\ R_M$, where R is radial distance from planetary center and R_M is Mercury's radius) are frequently observed by the orbiting MESSENGER spacecraft. These waves are not seen deeper in the tail ($R > 2\ R_M$). The ULF waves usually exhibit banded harmonic structure that drifts in frequency as the spacecraft traverses the magnetic equator. The waves are observed at all magnetic local times sampled during equator crossings. However, their rate of detection drops off strongly on the dayside, because dayside observations are limited by the presence of broad-band cusp emissions and the spacecraft on the dayside is usually located in the magnetosheath at low latitudes. For these reasons, we limit our investigation of these waves to the nightside magnetosphere. On average, the wave power is maximum at the equator and decreases with increasing magnetic latitude (MLAT), suggesting an equatorial source. When the spacecraft traverses strong diamagnetic depressions during its equatorial crossings, wave power is a factor of 10 larger than for equatorial crossings that do not cross marked depressions. The waves are predominantly transverse at large magnetic latitudes but tend to become compressional near the equator. Some events are marked by transverse waves at all MLATs, including the equator. A few of these events can be interpreted as ion cyclotron waves. In general, the waves tend to be strongly linear; they have ellipticity magnitudes < 0.3 and wave normal angles peaked near 90°. There are two hypotheses for the source of these waves. In the first, the waves are field-aligned resonances modified by the ion cyclotron frequencies, and their source consists of compressional waves generated in other regions of the magnetosphere and absorbed at the ion-ion resonances. Under the second hypothesis, the waves are generated near the magnetic equator in the nightside magnetosphere from highly unstable plasma-sheet ion distribution functions; the large planetary loss cone angle at Mercury, typically 30°, may play an important role in wave generation and would, in turn, further scatter these ions and enhance their precipitation onto the surface. It has been recently been suggested that the first mechanism is highly sensitive to the concentration of heavy ions such as Na^+ and also that variation in the Na^+ concentration will contribute to the drift in wave frequency. A detailed comparison of observed waves with the predictions of theoretical models provides a basis for further elucidating the source mechanism of these waves and the roles they play in Mercury's magnetosphere.